Fisheries and Oceans Science | Pêches et Océans Sciences

**CSAS** | **SCCS**

**Canadian Science Advisory Secretariat** | **Secrétariat canadien de consultation scientifique**

**Research Document 2001 /028** | **Document de recherche 2001 /028**

Not to be cited without permission of the authors * | Ne pas citer sans autorisation des auteurs *

# Status of Atlantic salmon at Highlands River, Bay St. George, SFA 13, Newfoundland, 2000

# État du stock de saumon atlantique de la rivière Highlands, tributaire de la baie St. George (ZPS 13), à Terre-Neuve

J. B. Dempson and G. Clarke

Science Branch
Fisheries and Oceans Canada
P. O. Box 5667
St. John's, Newfoundland, A1C 5X1

* This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

* La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au Secrétariat.

This document is available on the Internet at: http://www.dfo-mpo.gc.ca/csas/

Ce document est disponible sur l'Internet à:

ISSN 1480-4883
Ottawa, 2001

Canada

## Abstract

The status of Atlantic salmon in Highlands River, 2000, was determined from the number of salmon returning to a fish counting fence located on the main stem of the river just above head of tide. Biological characteristics were collected from kelt and updated summaries for past years are provided. Adult returns in 2000 were 58 small salmon and 67 large salmon. This was the lowest number of small salmon recorded at Highlands River and returns of large salmon were the lowest since monitoring resumed in 1993. Marine survival fell to the lowest value recorded for small salmon (0.6%) while survival to large salmon was only 1.1%. Marine survival is still anomalously low given the substantial reductions in directed sea fisheries for Atlantic salmon since 1992. The proportion of the conservation requirement achieved for Highlands River in 2000 was 34.0% with the 5$^{th}$ and 95$^{th}$ percentiles of 26.6 to 41.9%. On average, for the period 1993-2000, Highlands River has achieved 64.5% of its conservation requirement.



## Résumé

L'état du stock de saumon atlantique dans la rivière Highlands en 2000 est évalué d'après le nombre de saumon qui a passé à une barrière de dénombrement installée dans le bras principal de la rivière juste en amont de la ligne extrême des eaux de marée. Les caractéristiques biologiques des charognards recueillies sont utilisées pour mettre à jour les résumés de ces données recueillies au cours des dernières années. La remonte totalisait 58 petits saumons et 67 gros saumons, le nombre de petits saumons étant le plus faible enregistré dans cette rivière, alors que le nombre de gros saumons était le plus faible enregistré depuis la reprise de la surveillance en 1993. La survie en mer a chuté à une valeur encore jamais vue pour les petits saumons (0,6 %), tandis que le niveau pour les gros saumons n'atteignait que 1,1 %. La survie en mer demeure anormalement faible malgré la forte baisse de l'effort de pêche dirigée du saumon atlantique en mer depuis 1992. La ponte en 2000 dans la rivière Highlands a satisfait 34,0 % des besoins au titre de la conservation pour ce cours d'eau, l'intervalle entre les 5e et 95e centiles allant de 26,6 % à 41,9 %. En moyenne, la ponte dans la rivière Highlands pendant la période 1993-2000 a satisfait à 64,5 % des besoins au titre de la conservation.

## Introduction

Highlands River is a fourth order system located on the south west coast of Newfoundland (48° 11' 38'' N, 58° 53' 40" W), in Salmon Fishing Area (SFA) 13 (Fig. 1). The river drains westerly into Bay St. George from the southern part of the Long Range Mountains, with an average gradient of about 1.2%, over an axial length of 29.0 km. Area of the drainage basin is 183.1 $km^2$ (Gibson et al. 1987).

The river has long been noted for a fall run of very large salmon, and in the past, for good trout fishing (Palmer 1928). Owing to the decline of angling success, especially of the large salmon component, the river has been closed to angling since 1978 (Chadwick et al. 1978; Porter and Chadwick 1983; Gibson et al. 1987). In the 10-year period prior to the closure this fishery (1968 - 77), catches of small salmon ranged from 16 to 105 fish per year ($\bar{x}$ = 39.0 $year^{-1}$) while catch of large salmon varied from 4 to 25 ($\bar{x}$ = 11.8 $year^{-1}$). Prior to 1968, annual catches of 50 to 97 large salmon were reported (Moores et al. 1978).

Adult salmon spawning escapement and smolt yields were obtained from a fish counting fence that operated from 1980 to 1982, and again from 1993 to 2000. Over the period from 1993 to 1999, adult salmon returns have ranged from 96 to 398 small salmon ($\bar{x}$ = 185) and from 78 to 157 large salmon ($\bar{x}$ = 121). The highest returns occurred in 1997 (Reddin and Whalen 1998). Smolt production from 1993 to 1999 has varied from 5922 to 12383 ($\bar{x}$ = 9623), about 33% fewer than the average number of smolts in 1980 to 1982 ($\bar{x}$ = 14416). The fewest number of smolts occurred in 1997 and 1998. The low smolt runs were believed to have been the result of a severe flood that affected the river in February, 1996 (Reddin and Whalen 1998), the most extreme event recorded since 1982 (Dempson and Clarke 1999). Juvenile salmon population estimates were made in 1980 and 1981, and from 1993 to 1999 but were discontinued in 2000. Surveys carried out from 1997 - 1999 were based on a reduced subset (N = 5) of stations and thus were not as thorough as in previous years.

Based on past assessments (Gibson et al. 1994, 1996; Reddin and Whalen 1998), it was determined that less than 40% of the conservation requirement was achieved at Highlands River from 1980 to 1982. With the closure of the Newfoundland commercial salmon fishery in 1992, the percentage of the conservation requirement attained has averaged 68.9% (1993 - 1999) but in only one year, 1997, has the conservation spawning requirement been attained.

This paper summarizes smolt production and returns of adult Atlantic salmon to Highlands River in 2000. Biological characteristic data are updated along with hydrological conditions at Highlands River for the period 1982 - 2000 (2000 data preliminary).

## Methods

### 1. Environmental conditions

Water temperatures were obtained from a continuous recording Hugrun thermograph set 1 m from the surface at the fish counting fence site located in the lower river and operated from April 27 to October 27, 2000. Discharge information for the period 1982 - 2000 was obtained from Environment Canada records for the gauging station situated where the Trans Canada Highway crosses over the major stem of Highlands River ('River Brook'; Fig. 1). The drainage area above the water gauge is 72 $km^2$. This represents 39% of the total drainage area for the entire Highlands River watershed.

### 2. Biological characteristics

Biological characteristic information on smolts, including fork length to the nearest millimeter, whole weight to the nearest one hundredth of a gram, sex, and scales were derived from samples captured at the fish counting fence. Samples of adult salmon were obtained from kelt emigrating in the spring. Data were collected on fork length to the nearest centimeter, scales extracted for aging, and a visual inspection (external) was carried out to determine sex. Some returning adult salmon were also sampled for fork length to the nearest centimeter, scales and sex (external). Adult salmon fork length information (to the nearest 5 centimeters) in the past was obtained from returning adults based on a measuring stick placed along side of salmon in the trap. These data are provided for reference but we caution that, except for 1980 and 1981, the distributions should not be interpreted as reflecting the overall length distribution of the run in each year.

### 3. Smolt monitoring

Standard conduit smolt and adult counting fences were installed according to the description in Anderson and McDonald (1978). The smolt fence operated from May 6 until June 26, 2000, while adult salmon were monitored from June 22 to October 23 (Table 1).

### 4. Kelt tagging

As in 1998 and 1999, some of the kelt counted at the downstream fence in 2000 were tagged and released with individually numbered temperature recording archival tags (N = 14).

## 5. Adult salmon returns, sea survival and egg deposition

The adult fence was fished with every second conduit removed; therefore, smaller fish counted migrating upstream could be an underestimate since some could pass through the fence and not be counted at the trap. The trap was checked and fish released on a regular 4-hour basis from 0800 hrs to 2000 hrs (during the peak of the runs and during high water levels the trap was checked more frequently). The adult salmon counted were sized in two categories: 1) small salmon were those less than 63 cm in fork length; and 2) large salmon were fish 63 cm or greater.

Marine survival of smolts in year i was determined based on the number of small salmon returning in year i+1 and the number large salmon in year i+2. Adult salmon returning to Highlands River are characterized by several life-history types including virgin one sea-winter (1SW), two sea-winter (2SW), three sea-winter (3SW) and previous spawners of each of these life histories. Thus, an estimate of survival to the 2SW life history stage is also provided, but we caution that age data for adult large salmon are limited.

### *Spawning escapement*

Because Highlands River was closed to angling, total river returns (TRR) or spawning escapement (SE) were simply the numbers of fish enumerated at the fish counting fence. Egg deposition (ED) was calculated separately for small salmon ($< 63$ cm) and large salmon ($\geq 63$ cm) and then totaled:

$$ED = SE \times PF \times F$$

where, PF = proportion of females
F = fecundity at size.

For this assessment, egg deposition was been calculated as in the previous assessments (Dempson and Clarke 1999, 2000) using the average biological characteristic information (proportion females and mean lengths) obtained from samples of kelts, separately for small and large salmon, for two time periods 1980 - 1982, and 1993 - 1998. Mean values were used because the numbers of samples obtained in any specific year are generally limited:

| Size | | 1980 - 82 | 1994 - 98 |
|---|---|---|---|
| Small | % female (N) | 55.4 (74) | 46.1 (191) |
| | Mean length, cm (N) | 52.0 (41) | 53.1 (88) |
| Large | % female (N) | 75.0 (80) | 69.5 (203) |
| | Mean length, cm (N) | 85.2 (60) | 81.6 (141) |

Fecundity estimates were taken from Randall (1989):

Small salmon: Ln fecundity = -4.5636 + 3.1718 Ln (FL in cm); and,

Large salmon: Ln fecundity = -1.1862 + 2.3423 Ln (FL in cm).

The above equation for small salmon was originally derived for 1SW Miramichi River fish, while the equation used for large salmon was that derived from a composite of 2SW, 3SW and previous spawners from the Restigouche River.

*Conservation egg deposition requirement*

The conservation requirement for Highlands River is 1,498,475 eggs. This was derived from:

| | | |
|---|---|---|
| fluvial habitat | = | 6219.26 units @ 240 eggs/unit |
| lacustrine habitat | = | 15.9043 ha @ 368 eggs/ha |

(Reddin and Whalen 1998).

## 6. Avian observations

In 1999 and 2000, observations were made to document the occurrence of potential predators on salmon smolts. Observations were made at a location approximately one-half km downstream from the fish counting fence by counting fence personnel. Observations were taken one half hour after the first release of smolts in the morning and continued for approximately one hour. Time of day, species and number of birds (flying, standing, swimming) were recorded.

## Results and Discussion

### 1. Environmental conditions

*Water temperatures - 2000*

Mean daily water temperatures were generally cool in the spring, averaging less than 8 °C until May 14. Average daily water temperatures reached 10 °C for the first time on May 22 (Fig. 2), far later than in 1999 (May 7). Overall, May and June water temperatures averaged 8.2 and 14.5 °C, respectively. Temperatures increased quickly during the second half of June, but only reached a mean daily temperature of 20 °C for the first time on July 16 (Fig. 2), two weeks later than the previous year. There were 14 days in 2000 when the mean daily water temperature was 20 °C or warmer. Mean daily water temperature reached a peak value on August 5 at 21.9 °C, with a maximum temperature of 25.7 °C recorded on August 6. Over the entire summer, there were 36 days when maximum temperatures $\geq$ 22 °C were reached and 7 days when maximum temperatures $\geq$ 25 °C were obtained. With one exception, the latter occurred between the dates July 31 to August 6. Mean daily water temperatures declined sharply in late September with mean daily water temperatures remaining below 10 °C from October 12 onward.

*Water Discharge - 2000*

Preliminary discharge information, obtained from the Environment Canada station on Highlands River, indicated moderately high discharge in mid-May ($\bar{x}$ = 8.5 $m^3$/sec, May 12-20) with the remainder of the spring and summer characterized by low discharge (Fig. 2). From June through September, 2000, the highest mean daily discharge value was only 3.7 $m^3$/sec. A peak of 15.95 $m^3$/sec was recorded on October 20. A summary of past monthly values (mean, minimum and maximum discharges) are provided in Figure 3.

### 2. Biological characteristics

Table 2 summarizes the updated biological characteristic data of Atlantic salmon from Highlands River. Length and weight of smolts sampled in 2000 were similar to the average from all years (N= 2348; $\bar{x}$ = 129 mm and 20.3 g). Adult salmon have been partitioned into small and large categories with small salmon averaging 542 mm and large salmon 812 mm. All adult salmon data reported were obtained from kelts leaving the river during the spring of the year; only 17 adult salmon were sampled in 2000. The summary includes repeat spawners.

River age distribution of smolts is provided in Table 3. Smolts are predominately 3+ (72.7%) but there is considerable variation among years ranging from 58.1% river age 3 smolts in 1999 to 90.5% in 1998 (Table 3). The estimated contributions of 2+ smolts in 1999 (37.9%) and 2000 (25.6%) are the highest recorded and appear anomalous by comparison with previous information. In light of the 1996 extreme flood event at Highlands River, this could, perhaps, be evidence of a density dependent response given that smolt production at Highlands River in 1997 and 1998 declined by about 40% from the average production from 1993 - 1996. As recommended last year (Dempson and Clarke 2000), smolt age information from 1999 was reanalyzed with updated information contained in the present report.

Maximum, minimum and mean smolt lengths, by age class, are illustrated in Figure 4. Mean length of age 2+ smolts in 2000 was the highest over the past 8 years (back to 1993), and similar to the average sizes estimated in 1980 - 1982. Mean size of age 3+ smolts has similarly increased since 1993 (Fig. 4).

River age distributions of small and large adult salmon are summarized in Table 4. Small salmon are similarly characterized with a river age of 3+ years (73.5%) with 10.1% of the samples over all years having a river age of 2+ years. In contrast, 80.8% of the large salmon sampled had a river age of 3+ years while 16.2% smoltified as 2-year old smolts. As shown by O'Connell and Ash (1993) smaller and slower growing smolts in fluvial systems are often characterized by multi-sea winter large salmon.

Small salmon at Highlands River are predominantly 1SW fish (96.6%; $N_{small} = 328$) (Table 5). In contrast, of 338 large salmon kelt that have been sampled, 60.4% were maiden 2SW salmon while 29.6% were previous spawners (Table 5). Twelve (3.6%) virgin 3SW salmon have been sampled at Highlands River since 1980. These fish ranged from 87.0 to 105.0 cm in fork length.

Length-frequency distributions of adult salmon obtained from estimated lengths of fish in the fish counting fence trap are shown in Figure 5. Lengths were approximated from 93.6% of the adult salmon that returned in 2000.

## 3. Smolt monitoring

Numbers of smolts migrating downstream each year are summarized in Table 6. Smolt runs in 1997 (6776) and 1998 (5922) were the lowest recorded and believed to be a direct result of the extreme high water discharge events that affected Highlands River in February, 1996. Smolt runs in 1999 and again in 2000 have increased substantially over the 1996-1997 runs, with the 2000 production 36% higher than that of 1999 and the highest obtained over the 1993 to 2000 period.

Smolt run timing at Highlands River is illustrated in Figure 6. For the period 1993 - 1998, the median date of the smolt run was May 31, approximately two weeks later than

the smolt run at Conne River (May 18) (Dempson et al. 2000). The median date of the smolt run in 2000 was May 28, about a week later than in 1999.

In addition to Atlantic salmon parr (N= 806), smolts, and kelt (N = 29), both resident (N = 62) and sea-run (N = 217) brook trout, smelt and eels were enumerated passing downstream in 2000 (Table 6).

## 4. Kelt tagging

A total of 14 temperature-button tags were applied to kelts in the spring of 2000. The mean fork length was 66.8 cm (range: 54.0 - 96.0 cm). In contrast with the past two years, none of these fish were recovered in 2000. A summary of past kelt tagging and recaptures is provided in Table 7.

## 5. Adult salmon returns, sea survival and egg deposition

### *Adult salmon returns*

There were 58 small salmon and 67 large salmon enumerated at the fish counting fence in 2000 (Table 8, Fig. 7). This is the lowest number of small salmon observed at Highlands River, and is 68.6% lower than the 1993-1999 average return of small salmon. With respect to the large salmon component, returns in 2000 were the lowest since monitoring resumed in 1993 and 44.4% less than the 1993 - 1999.

### *Marine survival*

Marine survival of smolts that migrated in 1999 to small salmon returns in 2000 fell to 0.60% from 2.47% the previous year (Table 9); this was the lowest survival value recorded for small salmon returns at Highlands River. Estimates of the survival of the 1998 smolt class to large salmon returns and 2SW returns in 2000 were 1.13% and 0.68%, respectively (Table 9). As stated in previous assessments, despite major reductions in directed marine fisheries for Atlantic salmon, marine survival rates remain at disturbingly low values.

### *Egg deposition*

Potential egg deposition by small salmon was:

3088 eggs per fish x 58 small salmon x 0.461 proportion females = 82,567 eggs

Potential egg contribution from large salmon was:
9175 eggs per fish x 67 large salmon x 0.695 proportion females = 427,234 eggs

Total potential egg deposition was: 509,801 of which large salmon contributed 83.8%.

Thus, only 34% of the conservation spawning requirement was achieved in 2000 (509,801/1,498,475 = 34.0%), down from 48.8% in 1999 (Table 10). The average conservation requirement obtained over the period 1993 to 2000 is 64.5%, with the conservation spawning requirement achieved in only one year (1997).

In the above evaluation, only the numbers of small and large salmon returning to Highlands River in 2000 are known with certainty. To account for some of the uncertainty in the potential egg deposition that occurred, we assumed a coefficient of variation of 20% around the fecundity and percentage females of both small and large salmon components and recalculated the estimated egg depositions using 1000 realizations from a uniform distribution.

Based on this level of variation in fecundity and percentage females, the corresponding 5$^{th}$ and 95$^{th}$ percentiles of the percentage of the conservation requirement met varies from 26.6 to 41.9%.

## 6. Avian observations

Eleven groups or species of birds were observed at Highlands River in 1999 (Appendix 1) and 2000 (Appendix 2). Of these, the common merganser was the most common species observed in 1999 while gulls were the most common in 2000. Gulls were usually observed flying while mergansers were generally observed swimming. There were some instances where various groups were observed feeding, but it was not possible to identify with certainty prey organisms being selected.

## 7. Outlook for 2001

To achieve 100% of the conservation requirement in 2001, based upon the average egg deposition contribution from small (23.8%) and large salmon (76.2%) respectively over the past 8 years (1993 - 2000), marine survival rates approximating 1.91% for small salmon returns from 2000 smolts (~ 251 small salmon) and 1.86% for large salmon returns from the 1999 smolt class (~ 179 large salmon) would be required. While small salmon survival of this rate has been exceeded in the past (Table 9), a survival to large salmon of 1.86% has yet to be achieved at Highlands River during the years that the fish counting fence has been in operation.

**Acknowledgements**

We wish to acknowledge the assistance of the following individuals who through their efforts and interest in this project ensured a successful completion of all field operations during 2000: John Pumphrey, Donna Gilbert, Brian McInnis, Allan McInnis, Brian King, and Eric Legge. Special thanks are again extended to John MacPherson, Bay St. George South Development Association, who again coordinated the project and fish counting fence staff.

**References**

Anderson, T. C. and B. P. McDonald. 1978. A portable weir for counting migrating fishes in rivers. Fish. Mar. Serv. Tech. Rep. 733: 13 p.

Chadwick, E. M. P., T. R. Porter, and D. G. Reddin. 1978. Atlantic salmon management program, Newfoundland and Labrador, 1978. Atl. Salmon J. 1: 9-15.

Dempson, J. B., and G. Clarke. 1999. Status of Atlantic salmon at Highlands River, Bay St. George, SFA 13, Newfoundland, 1998. DFO Canadian Stock Assessment Secretariat Research Document 99/93. 44 p.

Dempson, J. B., and G. Clarke. 2000. Status of Atlantic salmon at Highlands River, Bay St. George, SFA 13, Newfoundland, 1999. DFO Canadian Stock Assessment Secretariat Research Document 2000/031. 43 p.

Dempson, J. B.. G. Furey, and M. Bloom. 2000. Status of Atlantic salmon in Conne River, SFA 11, Newfoundland, 1999. DFO Canadian Stock Assessment Secretariat Research Document 2000/032. 45 p.

Gibson, R. J., T. R. Porter, and K. G. Hillier. 1987. Juvenile salmonid production in the Highlands River, St. George's Bay, Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. No.1538. 109 p.

Gibson, R. J., J. P. King, and K. G. Hillier. 1994. Status of Atlantic salmon (*Salmo salar* L.) in the Highlands River, St. George's Bay (SFA 13), Newfoundland, 1993. DFO Atlantic Fisheries Research Document 94/89. 33 p.

Gibson, R. J., K. G. Hillier, and R. R. Whalen. 1996. Status of Atlantic salmon (*Salmo salar* L.) in the Highlands River, St. George's Bay (SFA 13), Newfoundland, 1995. DFO Atlantic Fisheries Research Document 96/39. 35 p.

Moores, R. B., R. W. Penney, and R. J. Tucker. 1978. Atlantic salmon angled catch and effort data, Newfoundland and Labrador, 1953-77. Fisheries and Marine Service Data Report No. 84, 274 p.

O'Connell, M. F., and E. G. M. Ash. 1993. Smolt size in relation to age at first maturity of Atlantic salmon (*Salmo salar*): the role of lacustrine habitat. J. of Fish Biology 42: 551-569.

Palmer, C. H. 1928. The salmon rivers of Newfoundland. Farrington Printing Co., Inc., Boston, Mass., U.S.A. 270 p.

Porter, T. R., and E. M. P. Chadwick. 1983. Assessment of Atlantic salmon stocks in Statistical Areas K and L, western Newfoundland, 1982. CAFSAC Research Document 83/87. 86 p.

Randall, R. G. 1989. Effect of sea-age on the reproductive potential of Atlantic salmon (*Salmo salar*) in eastern Canada. Can J. Fisheries & Aquatic Sciences 46: 2210-2218.

Reddin, D. G. and R. R. Whalen. 1998. Status of Atlantic salmon (*Salmo salar* L.) in Highlands River, Bay St. George (SFA 13), Newfoundland in 1997. DFO Canadian Stock Assessment Secretariat Research Document 98/113. 31 p.

Table 1. Summary of fish counting fence operation dates at Highlands River, SFA 13, Newfoundland.

| Year | Smolt counts | | Adult salmon counts | |
|---|---|---|---|---|
| | Start | Finish | Start | Finish |
| 1980 | May 7 | June 30 | May 7 | Oct 13 |
| 1981 | April 27 | - | - | Sept 9 |
| 1982 | May 23 | - | - | Sept 29 |
| - | | | | |
| 1993 | May 18 | June 16 | June 18 | Sept 28 |
| 1994 | May 18 | June 21 | June 22 | Oct 13 |
| 1995 | May 14 | June 8 | June 12 | Oct 25 |
| 1996 | April 26 | June 14 | June 14 | Oct 24 |
| 1997 | May 23 | July 14 | June 20 | Nov 2 |
| 1998 | May 6 | June 13 | June 14 | Oct 26 |
| 1999 | April 29 | June 23 | June 9 | Oct 31 |
| 2000 | May 6 | June 26 | June 22 | Oct 23 |

* Not operated from 1983 to 1992

Table 2. Summary of biological characteristics for Atlantic salmon samples from Highlands River, Newfoundland (SFA 13). Specimens of small and large salmon were obtained from sampling kelts when they were leaving the river in the spring of the year.

| Lifestage | Year | Fork length (mm) | | | | | Whole weight (g) | | | | | River age (y) | | | | | Sex Ratio | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | Mean | SD | Min | Max | N | Mean | SD | Min | Max | N | Mean | SD | Min | Max | N | % female |
| Smolt | 1980 | 337 | 132 | 12.5 | 100 | 173 | 337 | 22.0 | 5.9 | 8.7 | 44.4 | 337 | 2.80 | 0.47 | 2 | 4 | 324 | 66 |
| | 1981 | 261 | 127 | 9.8 | 94 | 159 | 248 | 19.5 | 4.2 | 9.3 | 38.0 | 261 | 2.89 | 0.54 | 2 | 5 | 248 | 70 |
| | 1982 | 324 | 131 | 16.5 | 83 | 180 | 324 | 21.1 | 7.2 | 5.4 | 48.0 | 324 | 2.92 | 0.51 | 2 | 5 | 282 | 71 |
| | 1983 | 118 | 118 | 15.5 | 76 | 160 | 118 | 16.9 | 5.9 | 4.4 | 37.1 | 118 | 2.92 | 0.63 | 2 | 6 | 117 | 66 |
| | 1984 | 164 | 122 | 10.7 | 96 | 154 | 164 | 16.5 | 4.5 | 7.9 | 31.8 | 164 | 3.21 | 0.52 | 2 | 4 | 164 | 63 |
| | 1985 | 178 | 129 | 12.8 | 102 | 169 | 177 | 20.3 | 6.1 | 10.7 | 54.0 | 178 | 3.20 | 0.51 | 2 | 5 | 178 | 65 |
| | 1986 | 239 | 127 | 12.8 | 85 | 171 | 236 | 19.3 | 5.7 | 5.3 | 43.7 | 239 | 2.87 | 0.53 | 1 | 4 | 208 | 67 |
| | 1987 | 137 | 129 | 11.5 | 102 | 165 | 137 | 20.2 | 5.4 | 11.3 | 39.8 | 137 | 2.92 | 0.44 | 2 | 4 | 137 | 63 |
| | 1988 | 126 | 137 | 10.8 | 106 | 169 | 126 | 23.0 | 5.3 | 13.0 | 41.0 | 126 | 3.03 | 0.31 | 2 | 4 | 68 | 62 |
| | 1999 | 196 | 129 | 13.7 | 101 | 167 | 196 | 20.4 | 6.5 | 10.0 | 39.7 | 196 | 2.66 | 0.55 | 2 | 4 | 102 | 56 |
| | 2000 | 266 | 131 | 13.7 | 106 | 197 | 266 | 20.9 | 7.3 | 10.6 | 70.5 | 266 | 2.76 | 0.48 | 2 | 4 | 134 | 69 |
| TOTAL | | 2348 | 129 | 13.7 | 76 | 197 | 2331 | 20.3 | 6.2 | 4.4 | 70.5 | 2348 | 2.90 | 0.52 | 1 | 6 | 1962 | 66 |
| Small | 1980 | 34 | 536 | 48.6 | 390 | 585 | | | | | | 34 | 2.97 | 0.39 | 2 | 4 | 34 | 41 |
| | 1981 | 14 | 552 | 37.4 | 490 | 620 | | | | | | 14 | 2.86 | 0.36 | 2 | 3 | 14 | 57 |
| | 1982 | 28 | 527 | 33.8 | 450 | 600 | 28 | 1093 | 253.8 | 500 | 1700 | 29 | 3.24 | 0.51 | 2 | 4 | 28 | 73 |
| | 1984 | 18 | 541 | 45.4 | 445 | 600 | | | | | | 18 | 3.17 | 0.38 | 3 | 4 | 18 | 28 |
| | 1985 | 8 | 583 | 31.1 | 515 | 600 | | | | | | 8 | 3.00 | 0.00 | 3 | 3 | 8 | 63 |
| | 1986 | 54 | 529 | 36.2 | 400 | 600 | | | | | | 54 | 3.15 | 0.49 | 2 | 4 | 54 | 48 |
| | 1987 | 84 | 556 | 46.5 | 420 | 625 | | | | | | 84 | 3.07 | 0.60 | 2 | 4 | 84 | 39 |
| | 1988 | 27 | 544 | 38.5 | 485 | 625 | | | | | | 27 | 3.07 | 0.55 | 2 | 4 | 27 | 70 |
| | 1999 | 51 | 539 | 36.3 | 480 | 620 | | | | | | 51 | 2.96 | 0.56 | 2 | 4 | 8 | 63 |
| | 2000 | 10 | 558 | 53.6 | 475 | 620 | | | | | | 10 | 3.00 | 0.00 | 3 | 3 | 9 | 44 |
| TOTAL | | 328 | 542 | 42.5 | 390 | 625 | 28 | 1093 | 253.8 | 500 | 1700 | 328 | 3.06 | 0.51 | 2 | 4 | 282 | 49 |
| Large | 1980 | 26 | 896 | 111.6 | 710 | 1100 | | | | | | 26 | 2.82 | 0.50 | 2 | 3 | 26 | 65 |
| | 1981 | 43 | 820 | 87.7 | 630 | 1050 | | | | | | 43 | 2.84 | 0.37 | 2 | 3 | 43 | 86 |
| | 1982 | 12 | 845 | 102.3 | 650 | 1100 | 12 | 4100 | 1009.1 | 2200 | 6000 | 12 | 2.92 | 0.29 | 2 | 3 | 11 | 55 |
| | 1984 | 18 | 782 | 82.9 | 645 | 1000 | | | | | | 18 | 3.06 | 0.24 | 3 | 4 | 18 | 56 |
| | 1985 | 31 | 782 | 78.9 | 630 | 1000 | | | | | | 31 | 2.90 | 0.40 | 2 | 4 | 31 | 77 |
| | 1986 | 40 | 806 | 90.7 | 645 | 1030 | | | | | | 40 | 2.98 | 0.28 | 2 | 4 | 40 | 70 |
| | 1987 | 87 | 811 | 90.4 | 635 | 1120 | | | | | | 87 | 2.90 | 0.40 | 2 | 4 | 87 | 70 |
| | 1988 | 27 | 819 | 90.0 | 630 | 1035 | | | | | | 27 | 2.74 | 0.45 | 2 | 3 | 27 | 67 |
| | 1999 | 47 | 786 | 99.8 | 630 | 1040 | | | | | | 47 | 2.79 | 0.51 | 2 | 4 | 26 | 69 |
| | 2000 | 7 | 773 | 136.8 | 635 | 980 | | | | | | 7 | 3.29 | 0.49 | 3 | 4 | 7 | 71 |
| TOTAL | | 338 | 812 | 96.8 | 630 | 1120 | 12 | 4100 | 1009.1 | 2200 | 6000 | 338 | 2.87 | 0.42 | 2 | 4 | 316 | 71 |

Table 3. Estimated total numbers of smolts in each age class at Highlands River, Bay St. George, Newfoundland. The percentage in each age class is shown in the lower part of the table. Information has been updated from last year following reanalysis of some some smolt ages.

| Year | River age (years) 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|
| 1980 | 3426 | 11151 | 451 | 0 | 0 | 15028 |
| 1981 | 3152 | 11467 | 1093 | 127 | 0 | 15839 |
| 1982 | 2142 | 9174 | 1027 | 37 | 0 | 12380 |
| 1993 | 2027 | 6940 | 849 | 85 | 85 | 9986 |
| 1994 | 515 | 7236 | 2752 | 0 | 0 | 10503 |
| 1995 | 547 | 8682 | 2870 | 61 | 0 | 12160 |
| 1996 | 2440 | 8965 | 978 | 0 | 0 | 12383 |
| 1997 | 942 | 5441 | 393 | 0 | 0 | 6776 |
| 1998 | 190 | 5359 | 373 | 0 | 0 | 5922 |
| 1999 | 3851 | 5598 | 385 | 0 | 0 | 9834 |
| 2000 | 3359 | 9617 | 144 | 0 | 0 | 13120 |

| Year | Percent in each age class 2 | 3 | 4 | 5 | 6 | Number of samples |
|---|---|---|---|---|---|---|
| 1980 | 22.8 | 74.2 | 3.0 | 0 | 0 | 337 |
| 1981 | 19.9 | 72.4 | 6.9 | 0.8 | 0 | 281 |
| 1982 | 17.3 | 74.1 | 8.3 | 0.3 | 0 | 324 |
| 1993 | 20.3 | 69.5 | 8.5 | 0.8 | 0.8 | 118 |
| 1994 | 4.9 | 68.9 | 26.2 | 0 | 0 | 164 |
| 1995 | 4.5 | 71.4 | 23.6 | 0.6 | 0 | 178 |
| 1996 * | 19.7 | 72.4 | 7.9 | 0 | 0 | 239 |
| 1997 | 13.9 | 80.3 | 5.8 | 0 | 0 | 137 |
| 1998 | 3.2 | 90.5 | 6.3 | 0 | 0 | 126 |
| 1999 | 37.9 | 58.1 | 4.0 | 0 | 0 | 198 |
| 2000 | 25.6 | 73.3 | 1.1 | 0 | 0 | 266 |
| Total | 18.7 | 72.7 | 8.4 | 0.2 | 0.0 | 2348 |

* One river age 1 smolt reported

Table 4. River age distribution (%) of small and large salmon sampled as kelt leaving Highlands River, Bay St. George, Newfoundland.

**Small salmon**

| Year | Percent in each age class | | | | Number of samples |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | |
| 1980 | 8.8 | 85.3 | 5.9 | 0 | 34 |
| 1981 | 14.3 | 85.7 | 0 | 0 | 14 |
| 1982 | 3.6 | 67.9 | 28.6 | 0 | 28 |
| 1993 | - | - | - | - | - |
| 1994 | 0 | 83.3 | 16.7 | 0 | 18 |
| 1995 | 0 | 100.0 | 0 | 0 | 8 |
| 1996 | 5.6 | 74.1 | 20.4 | 0 | 54 |
| 1997 | 14.3 | 64.3 | 21.4 | 0 | 84 |
| 1998 | 11.1 | 70.4 | 18.5 | 0 | 27 |
| 1999 | 17.7 | 68.6 | 13.7 | | 51 |
| 2000 | 0.0 | 100.0 | 0.0 | 0 | 10 |
| Total | 10.1 | 73.5 | 16.4 | 0 | 328 |

**Large salmon**

| Year | Percent in each age class | | | | Number of samples |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | |
| 1980 | 38.5 | 61.5 | 0 | 0 | 26 |
| 1981 | 16.3 | 83.7 | 0 | 0 | 43 |
| 1982 | 8.3 | 91.7 | 0 | 0 | 12 |
| 1993 | - | - | - | - | - |
| 1994 | 0 | 94.4 | 5.6 | 0 | 18 |
| 1995 | 13 | 83.9 | 3.2 | 0 | 31 |
| 1996 | 5.0 | 92.5 | 2.5 | 0 | 40 |
| 1997 | 13.8 | 82.8 | 3.5 | 0 | 87 |
| 1998 | 25.9 | 74.1 | 0 | 0 | 27 |
| 1999 | 25.5 | 70.2 | 4.3 | 0 | 47 |
| 2000 | 0.0 | 71.4 | 28.6 | 0 | 7 |
| Total | 16.2 | 80.8 | 3.0 | 0 | 338 |

Table 5. Sea age distribution of small and large salmon sampled as outmigrating kelt at Highlands River, Newfoundland, where 1SW, 2SW and 3SW refer to virgin sea ages.

| | Small salmon (Fork length < 63 cm) | | | | Large salmon (Fork length >= 63 cm) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Number | 1SW | 2SW | PS | Number | 1SW | 2SW | 3SW | PS * |
| 1980 | 34 | 34 | | | 26 | | 13 | 5 | 8 |
| 1981 | 14 | 14 | | | 43 | 2 | 37 | 2 | 2 |
| 1982 | 28 | 28 | | | 12 | 1 | 10 | | 1 |
| 1994 | 18 | 18 | | | 18 | | 14 | | 4 |
| 1995 | 8 | 8 | | | 31 | 5 | 24 | 1 | 1 |
| 1996 | 54 | 53 | 1 | | 40 | | 24 | | 16 |
| 1997 | 84 | 77 | 1 | 6 | 87 | 1 | 47 | 3 | 36 |
| 1998 | 27 | 27 | | | 27 | 2 | 15 | 1 | 9 |
| 1999 | 51 | 48 | | 3 | 47 | 7 | 18 | | 22 |
| 2000 | 10 | 10 | | | 7 | 4 | 2 | | 1 |
| Total | 328 | 317 | 2 | 9 | 338 | 22 | 204 | 12 | 100 |

* Of the 100 previous spawning large salmon sampled, 78 (78%) had a virgin sea age of 2, 20 (20%) had a virgin sea age of 1, while two (2.0%) had a virgin sea age of 3.

Table 6. Numbers of downstream migrating fish enumerated at the Highlands River fish counting fence.

| Year | Numbers of fish migrating downstream | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Atlantic salmon | | | Brook trout | | | | |
| | Parr | Smolt | Kelt | Resident | Sea-run | Smelt | Eels | Killifish |
| 1980 | 339 | 15028 | 73 | 796 | 814 | 35 | 1486 | 4 |
| 1981 | 199 | 15839 | 63 | 702 | 514 | 13 | 929 | 5 |
| 1982 | 375 | 12380 | 59 | 1293 | 0 | 19 | 439 | 0 |
| 1993 | 877 | 9986 | 90 | 731 | 0 | 43 | 162 | 0 |
| 1994 | 1345 | 10503 | 57 | 759 | 204 | 16 | 188 | 0 |
| 1995 | 152 | 12160* | 43 | 33 | 503 | 13 | 7 | 0 |
| 1996 | 1111 | 12383 | 110 | 238 | 303 | 16 | 10 | 0 |
| 1997 | 196 | 6776 | 192 | 58 | 457 | 41 | 9 | 0 |
| 1998 | 133 | 5922 | 69 | 2 | 84 | 6 | 8 | 0 |
| 1999 | 295 | 9634 | 126 | 91 | 473 | 14 | 31 | 0 |
| 2000 | 806 | 13120 | 29 | 62 | 217 | 23 | 239 | 0 |

* The 1995 smolt count was adjusted to account for a washout that occurred during the latter part of the smolt run. The unadjusted count was 9009 smolts.

Table 7. Highlands River Atlantic salmon kelt tag release and recapture information, 1998 - 2000.

| Release Information | | | | Recapture Information | | | Area of Recapture | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tagging Location | Year | Tag Type | Number Tagged | Total Number Recaptured | Year | Number | Highlands River | Humber River | Humber Estuary | Port au Port Sentinel Fishery | Quebec North Shore |
| Highlands River | 1998 | Archival | 24 | 6 | 1998 | 6 | 4 | | | 1 | 1 |
| | | Carlin | 32 | 6 | 1998 | 3 | 2 | | | | 1 |
| | | | | | 1999 | 3 | 2 | | 1 | | |
| | | | | | 2000 | 1 | 1 | | | | |
| | 1999 | Archival | 29 | 7 | 1999 | 7 | 6 | 1 | | | |
| | | Carlin | 37 | 4 | 1999 | 4 | 4 | | | | |
| | 2000 | Button | 14 | 0 | | | | | | | |
| Total | | | 136 | 23 | | 24 | 19 | 1 | 1 | 1 | 2 |

Table 8. Numbers of upstream migrating fish enumerated at the Highlands River fish counting fence.

| Year | Numbers of fish migrating upstream | | | | |
|---|---|---|---|---|---|
| | Atlantic salmon | | | Brook trout | |
| | Small | Large | % small | Resident | Sea-run |
| 1980 | 82 | 55 | 59.9 | 0 | 10 |
| 1981 | 127 | 29 | 81.4 | 0 | 11 |
| 1982 | 100 | 56 | 64.1 | 0 | 15 |
| 1993 | 137 | 78 | 63.7 | 0 | 63 |
| 1994 | 145 | 148 | 49.5 | 74 | 208 |
| 1995 | 172 | 120 | 58.9 | 2 | 16 |
| 1996 | 199 | 142 | 58.4 | 0 | 10 |
| 1997 | 398 | 157 | 71.7 | 0 | 6 |
| 1998 | 96 | 117 | 45.1 | 0 | 0 |
| 1999 | 146 | 82 | 64.0 | 0 | 0 |
| 2000 | 58 | 67 | 46.4 | 0 | 2 |

Table 9. Estimated survival of smolts in year i to small salmon in year i + 1, and to large salmon or 2SW salmon in year i + 2, at Highlands River, Newfoundland.

| Year (i) | Number of Smolts (year i) | % survival to small salmon (year i + 1) | % survival to large salmon (year i + 2) | % survival to 2SW salmon (year i + 2) |
|---|---|---|---|---|
| 1980 | 15028 | 0.85 | 0.37 | 0.31 |
| 1981 | 15839 | 0.63 | - | - |
| 1993 | 9986 | 1.45 | 1.20 | 0.93 |
| 1994 | 10503 | 1.64 | 1.35 | 0.81 |
| 1995 | 12160 | 1.64 | 1.29 | 0.70 |
| 1996 | 12383 | 3.21 | 0.94 | 0.52 |
| 1997 | 6776 | 1.42 | 1.21 | 0.46 |
| 1998 | 5922 | 2.47 | 1.13 | 0.68 |
| 1999 | 9634 | 0.60 | - | - |

* For 2SW survival in 2000, from 1998 smolts, life-history age data from all years combined were used owing to small sample size of large fish in 2000.

Table 10. Values used in the determination of the level of conservation requirements met at Highlands River, Bay St. George, Newfoundland, based upon an egg requirement of 1.498 million eggs.

| Year | Small salmon | | | | Large salmon | | | | Total No. of eggs small and large salmon | % contribution from large salmon | % conservation level achieved |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | % female | No. of eggs per fish | No. of eggs | Number | % female | No. of eggs per fish | No. of eggs | | | |
| 1980 | 82 | 0.554 | 2890 | 131287 | 55 | 0.75 | 10151 | 418729 | 550016 | 76.1 | 36.7 |
| 1981 | 127 | 0.554 | 2890 | 203335 | 29 | 0.75 | 10151 | 220784 | 424119 | 52.1 | 28.3 |
| 1982 | 100 | 0.554 | 2890 | 160106 | 56 | 0.75 | 10151 | 426342 | 586448 | 72.7 | 39.1 |
| 1993 | 137 | 0.461 | 3088 | 195029 | 78 | 0.695 | 9175 | 497377 | 692406 | 71.8 | 46.2 |
| 1994 | 145 | 0.461 | 3088 | 206417 | 148 | 0.695 | 9175 | 943740 | 1150158 | 82.1 | 76.8 |
| 1995 | 172 | 0.461 | 3088 | 244854 | 120 | 0.695 | 9175 | 765195 | 1010049 | 75.8 | 67.4 |
| 1996 | 199 | 0.461 | 3088 | 283290 | 142 | 0.695 | 9175 | 905481 | 1188771 | 76.2 | 79.3 |
| 1997 | 398 | 0.461 | 3088 | 566580 | 157 | 0.695 | 9175 | 1001130 | 1567710 | 63.9 | 104.6 |
| 1998 | 96 | 0.461 | 3088 | 136663 | 117 | 0.695 | 9175 | 746065 | 882728 | 84.5 | 58.9 |
| 1999 | 146 | 0.461 | 3088 | 207841 | 82 | 0.695 | 9175 | 522883 | 730724 | 71.6 | 48.8 |
| 2000 | 58 | 0.461 | 3088 | 82567 | 67 | 0.695 | 9175 | 427234 | 509801 | 83.8 | 34.0 |

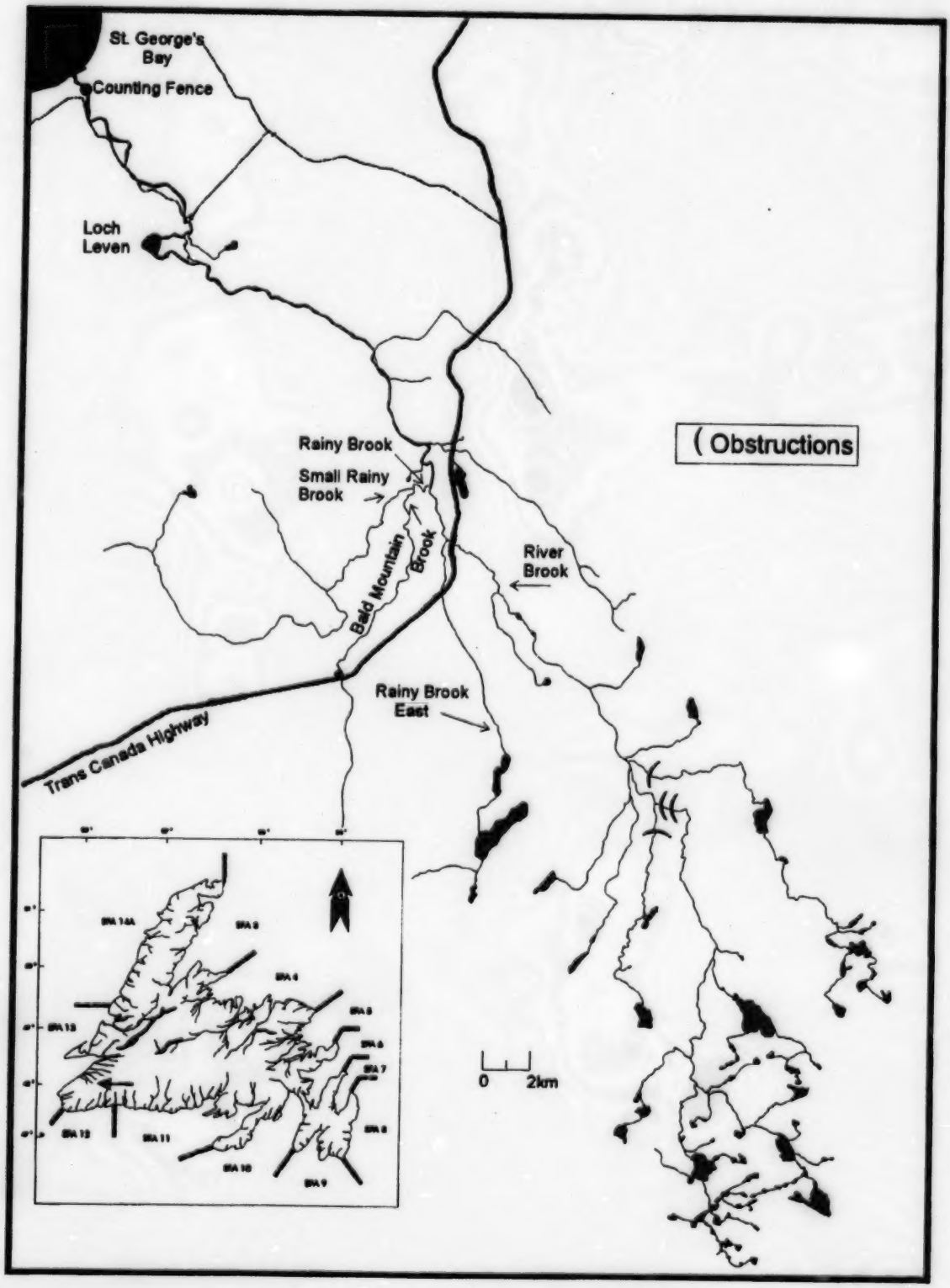


Fig. 1. Location of Highlands River, SFA 13, Newfoundland.

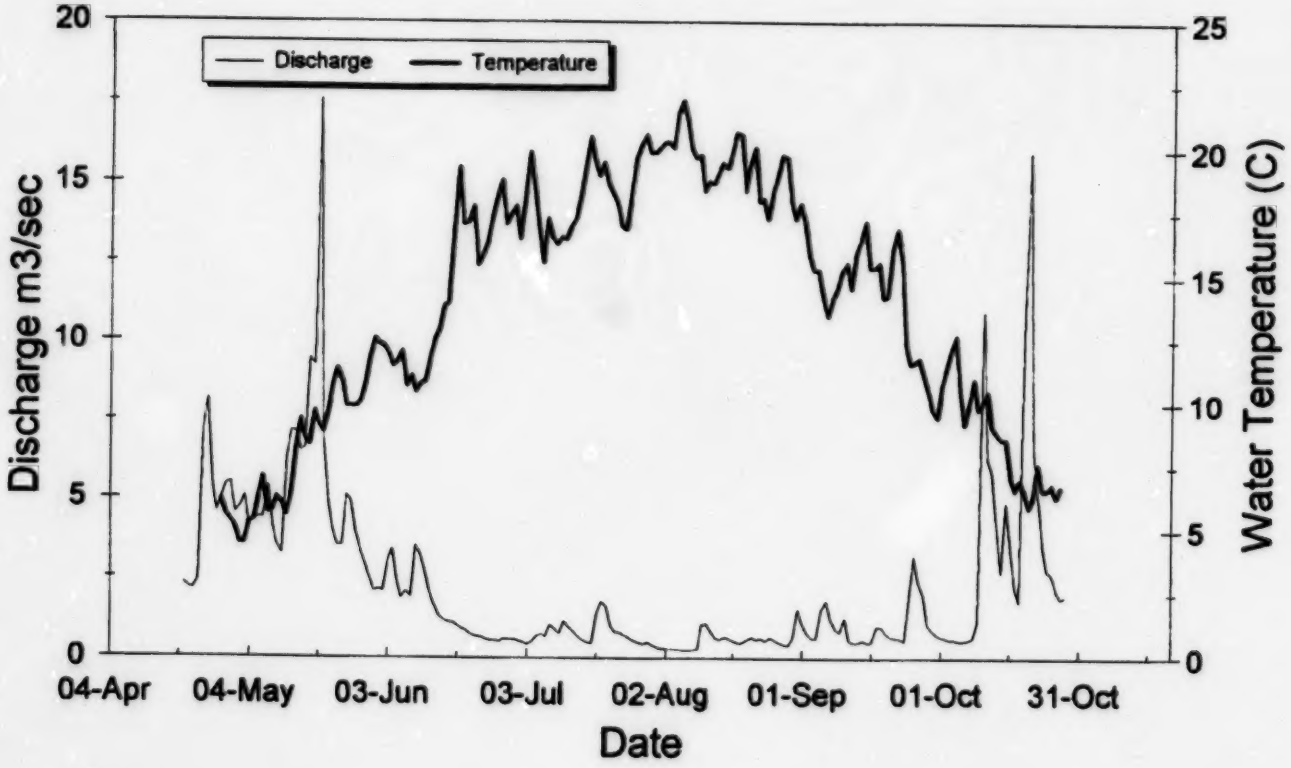


Fig. 2. Mean daily discharge (m3/s) and water temperature (C) at Highlands River, SFA 13, 2000.

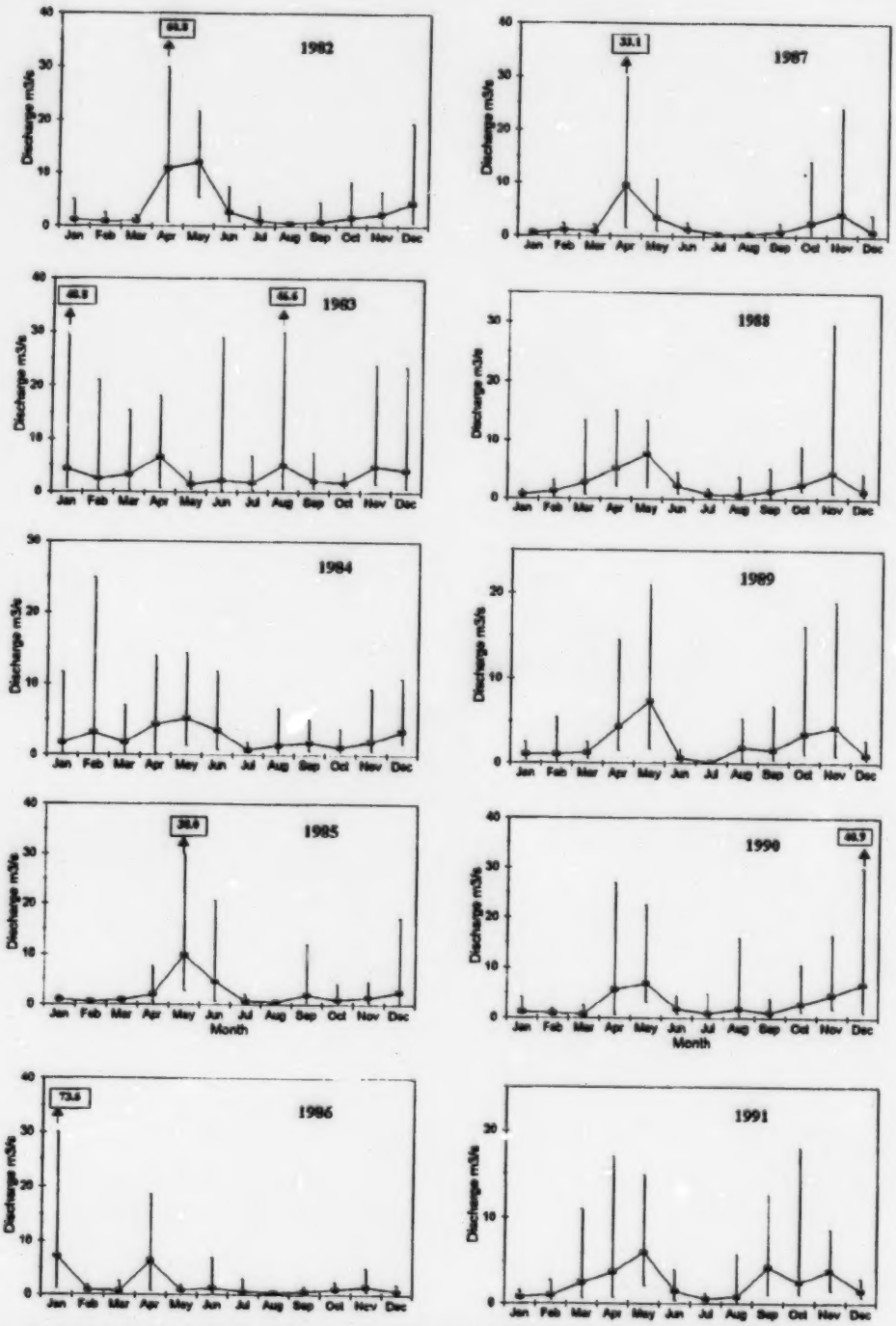


Fig. 3. Summary of maximum, minimum and mean daily discharge by month for Highlands River, Newfoundland, 1982 - 1991. Mean values are joined by a continuous line. Maximum values exceeding 30 m $^3$/s are shown as a separate box for the respective months in which these high values occurred.

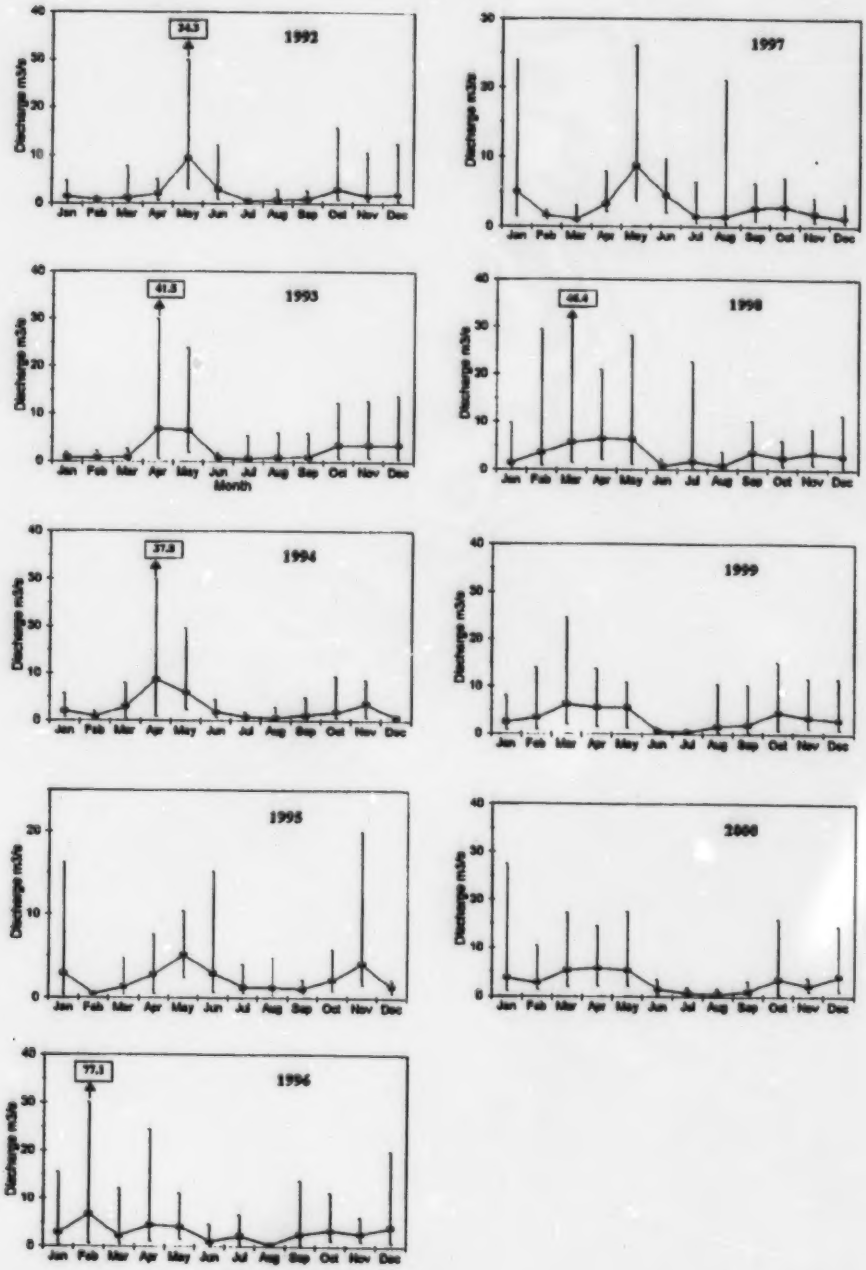


Fig. 3, continued. Summary of maximum, minimum and mean daily discharge by month for Highlands River, Newfoundland, 1992 - 2000. Mean values are joined by a continuous line. Maximum values exceeding 30 $m^3/s$ are shown as a separate box for the respective months in which these high values occurred.
NOTE: Information for 2000 is PRELIMINARY.

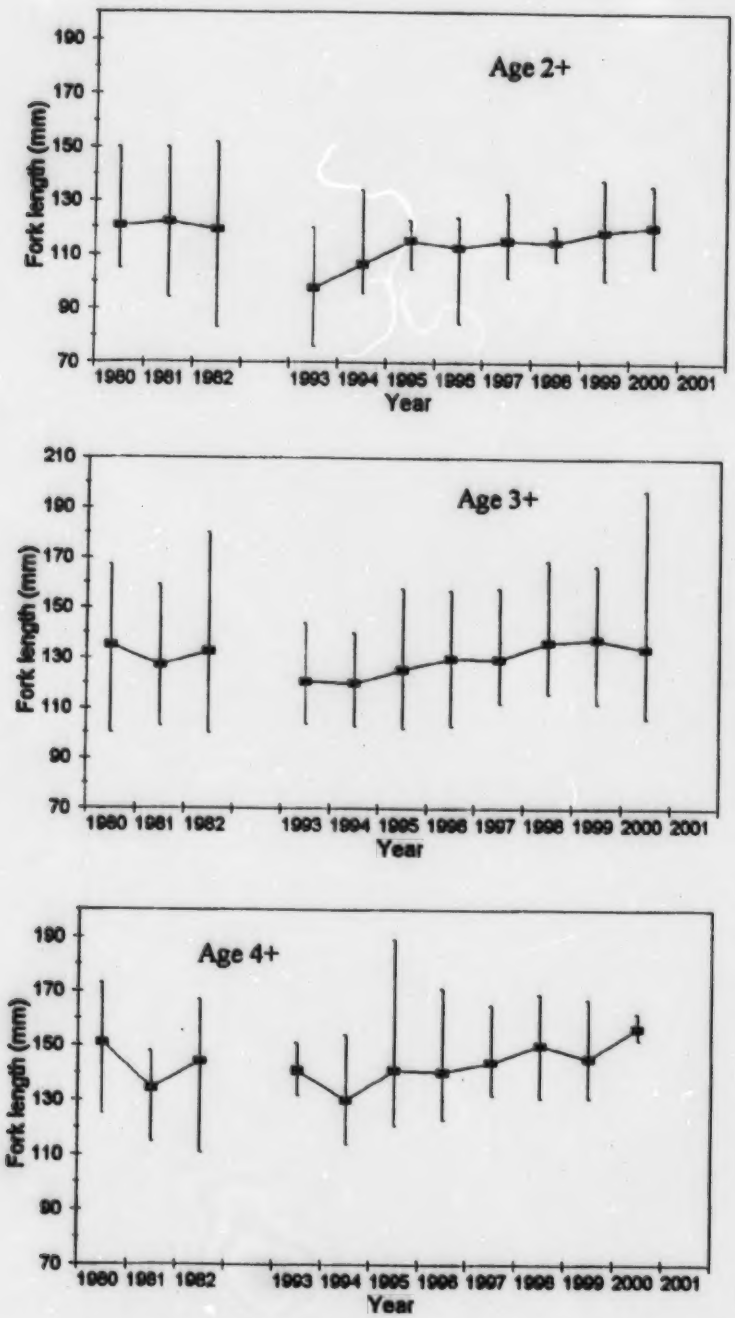


Fig. 4. Minimum, maximum, and mean fork length (mm) of river age 2+, 3+, and 4+ Highlands River smolt, from 1980 - 1982, and 1993 - 2000.

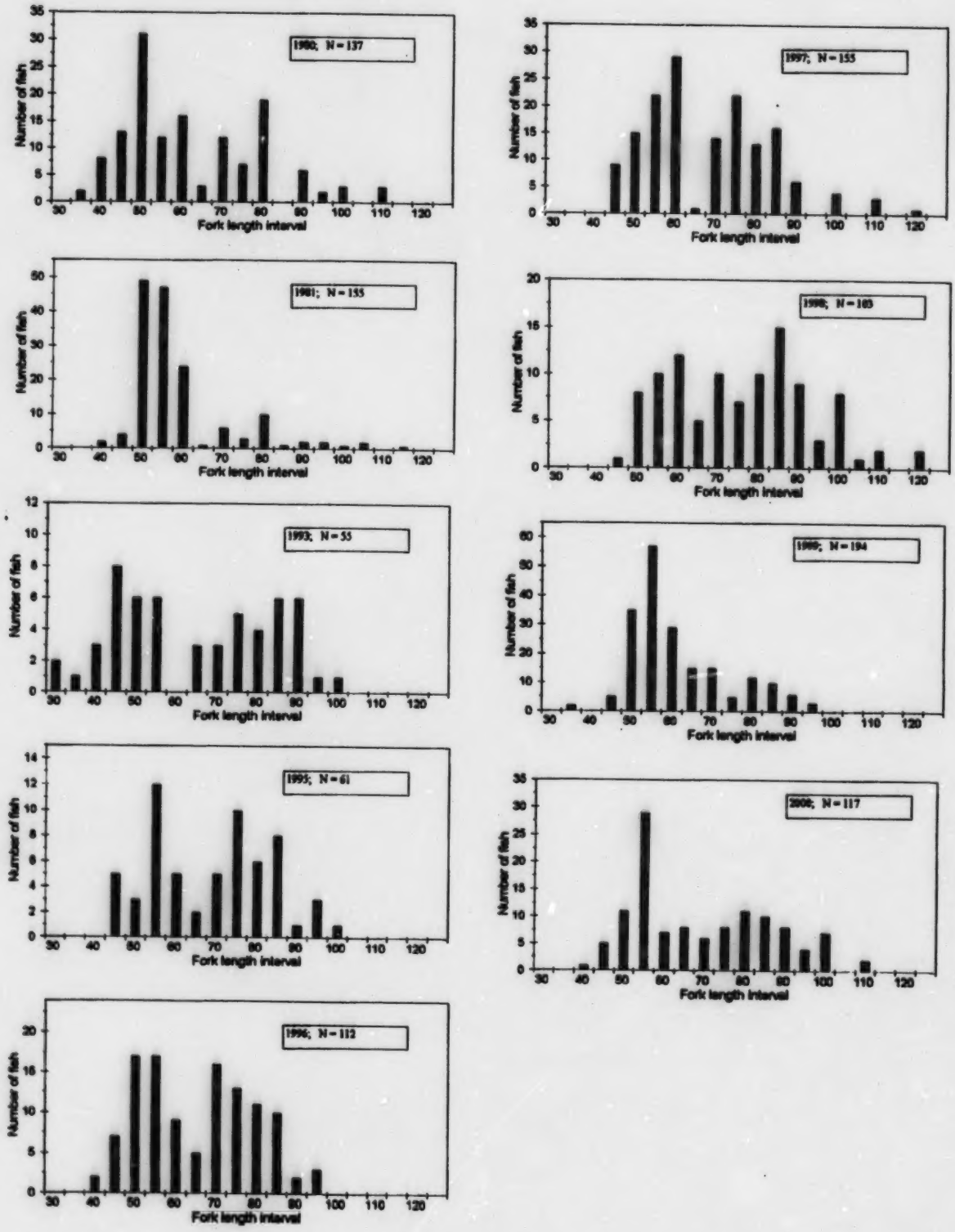


Fig. 5. Length distributions of adult Atlantic salmon estimated from fish in the fish counting fence trap at Highlands River, Newfoundland.

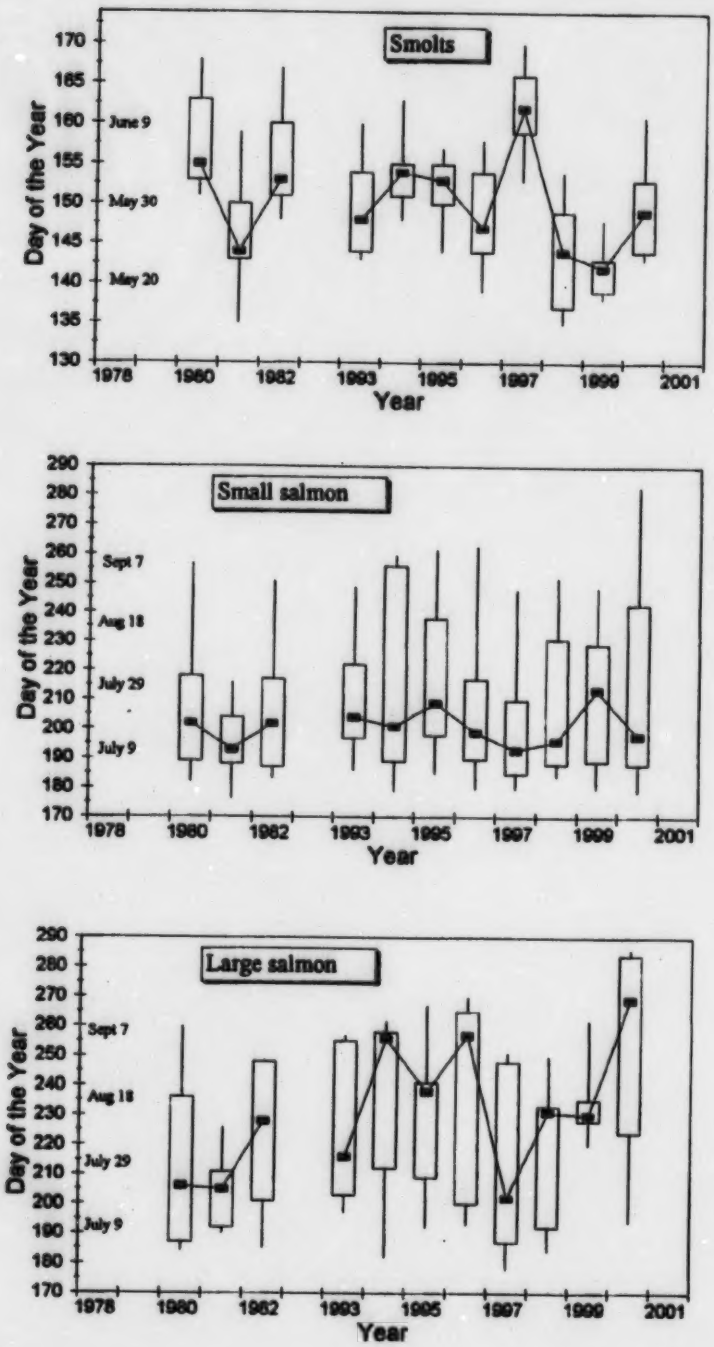


Fig. 6. Annual variation in run timing of Highlands River smolts, small and large salmon. Vertical lines represent the 10th and 90th percentiles of the day of the year of migration, the rectangle is the 25th and 75th percentiles, and the marker within the rectangle is the median run timing.

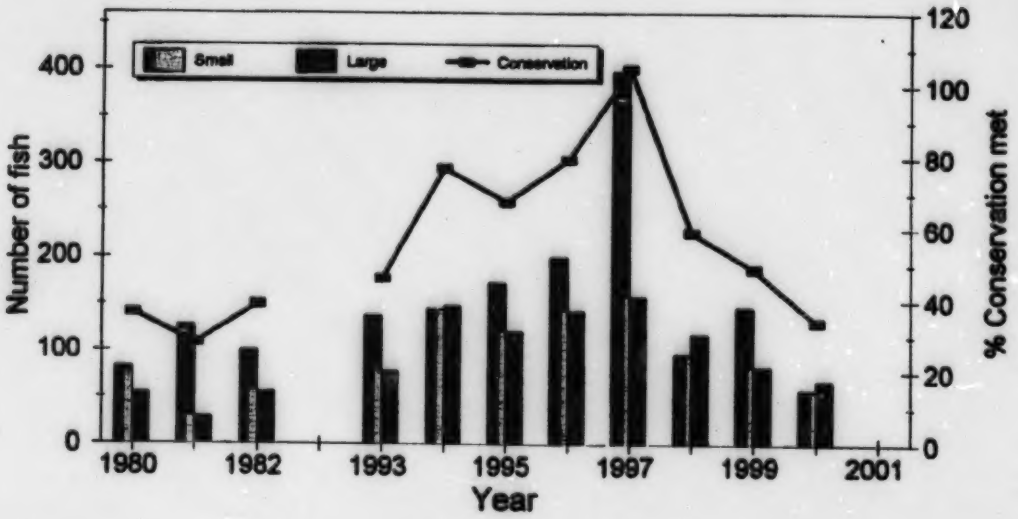


Fig. 7. Total numbers of small and large salmon returning to Highlands River, Newfoundland, along with the estimated percentage of the conservation requirement met.

Appendix 1. Highlands River avian and seal observations, 1999.

| Species/Group | Activities observed | | | |
|---|---|---|---|---|
| | Flying | Standing | Swimming | Feeding |
| Common Merganser | 4 | | 259 | |
| Kingfisher | 5 | | | |
| Tern | 24 | | | 6 |
| Seagull | 159 | 1 | 3 | |
| Bald Eagle | 1 | 2 | | |
| Loon | | | 14 | |
| Cormorant | 8 | 34 | 18 | |
| Hawk | 4 | | | |
| Crow | 4 | | | |
| Osprey | 1 | | | |
| Seals | | | 2 | 1 |

Appendix 2. Highlands River avian and seal observations, 2000.

| Species/Group | Activities observed | | | |
|---|---|---|---|---|
| | Flying | Standing | Swimming | Feeding |
| Common Merganser | 10 | 2 | 42 | 17 |
| Kingfisher | 19 | 4 | | |
| Tern | 7 | | | 6 |
| Gull | 151 | 1 | 2 | 8 |
| Crow | 6 | | | |
| Raven | 1 | | | |
| Hawk | 1 | | | |
| Bald Eagle | 1 | | | |

There were four (4) seals observed at the mouth of Highlands River on the 15th of September 2000 possibly feeding.

**STOCK:** **Highlands River (SFA 13)** **Drainage area:** 183 km²

**CONSERVATION REQUIREMENT:** 1.5 million eggs calculated as fluvial area x 2.4 eggs/m² and lacustrine area x 368 eggs/ha

| Year | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 [2] | MIN [1] | MAX [1] |
|---|---|---|---|---|---|---|---|---|
| **Total returns to home waters** | | | | | | | | |
| Small | 172 | 199 | 398 | 96 | 146 | 58 | 58 | 398 |
| Large | 120 | 142 | 157 | 117 | 82 | 67 | 29 | 157 |
| **Recreational harvest (small salmon)** | | | | | | | | |
| Retained | | | | | | | | |
| Released | | | | | | | | |
| **Recreational harvest (large salmon)** | | | | | | | | |
| Retained | | | | | | | | |
| Released | | | | | | | | |
| **Spawners** | | | | | | | | |
| Small | 172 | 199 | 398 | 96 | 146 | 58 | 58 | 398 |
| Large | 120 | 142 | 157 | 117 | 82 | 67 | 29 | 157 |
| **Conservation requirement** | | | | | | | | |
| % met | 67 | 79 | 105 | 59 | 49 | 34 | 28 | 105 |
| **Smolt count** | 12160 | 12383 | 6776 | 5922 | 9634 | 13120 | 5922 | 15839 |
| **% Sea survival** | | | | | | | | |
| Small | 1.6 | 1.6 | 3.2 | 1.4 | 2.5 | 0.6 | 0.6 | 3.2 |
| Large | 1.2 | 1.4 | 1.3 | 0.9 | 1.2 | 1.1 | 0.4 | 1.4 |
| (Adult return year) | | | | | | | | |

[1] Min and max are for the period of record since 1974.
[2] Preliminary

**Data and methodology:** Counts of smolt and adult salmon were obtained with a fish counting fence in 1980 - 82 and in 1993 - 2000. Sea survival is calculated for small salmon returning in year i + 1 and for large salmon returning in year i + 2, by dividing the number of returning adults by the number of smolts in year i.

**State of the stock:** The number of large salmon returning has increased since the closure of the commercial salmon fishery in 1992, but has fallen in each of the past three years since the peak in 1997. Small salmon returns are variable with returns in 2000 the lowest recorded. The conservation spawning requirement was achieved in only one year (1997) and fell to The conservation spawning requirement was achieved in only one year (1997) and fell to 34% of the requirement in 2000.

**Forecast:** The conservation spawning requirement will likely not be met in 2001 unless there is a substantial increase in marine survival rates. Based upon the average egg deposition contribution from small and large salmon, respectively, over the past 8 years (1993 - 2000), marine survival rates approximating 1.91% for small salmon returns from the 2000 smolt class and 1.86% survival for large salmon returns from the 1999 smolt class would be required. To date, the highest survival to large salmon has been only 1.35%.